Dec. 30, 1952 W. J. POLYDOROFF 2,624,004

FERROMAGNETIC ANTENNA

Filed May 16, 1952

FIG. 1.

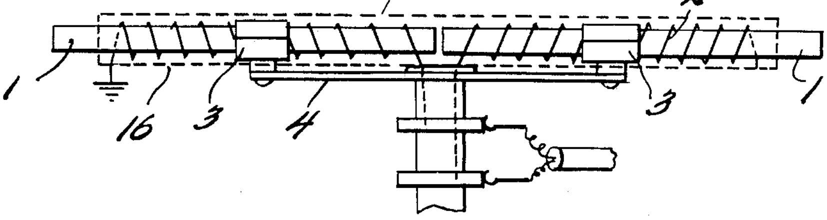


FIG. 2a

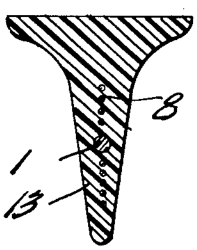


FIG. 2.

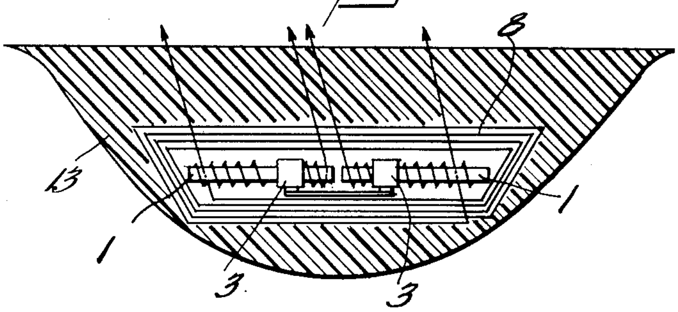


FIG. 3.

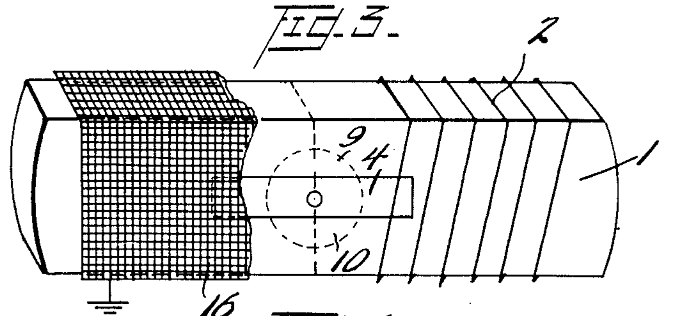
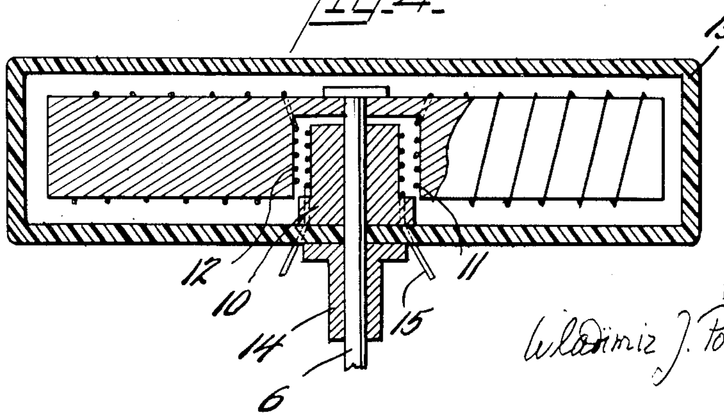


FIG. 4.



INVENTOR

Wladimir J. Polydoroff

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FERROMAGNETIC ANTENNA

Wladimir J. Polydoroff, Kensington, Md.

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10 Claims. (Cl. 250—33.67)

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This invention relates to ferromagnetic loop antennas, which generally comprise a magnetic mass and a pick-up coil wound around said mass in a form of a core, such as was described in my U. S. Patent 2,266,262. The magnetic material and the coil should be of such characteristics as to respond to the high frequency radiations, when such antenna is placed in a high frequency field. The lines of force of electromagnetic radiations should readily pass through the core in order to generate induced currents in the coil, hence the core should be of "open" magnetic structure.

It has been proven that the pick-up properties of such antenna, as expressed in term of "effective height" (h_{eff}) are increased by the amount substantially equal to the effective permeability of the core in the given coil and when the inductance L of the antenna is limited to a certain operational value the increase of inductance due to the core should be reduced by reducing the number of turns, N with the net gain in effective height being equal to μ_{eff}.

At the time of the above mentioned patent the high frequency materials possessed initial permeabilities not over 50 which in short-coil-core constructions yielded effective permeabilities not over 5. Lengthening of the loop would considerably increase the bulk and weight of such loops.

The present invention utilizes the applications of new high frequency materials known as ferrites which possess initial permeabilities of the order of 100 to 500 and whose core losses permit their employment in the region of frequencies from 200 kc. to 2 mc.

Such high permeabilities cannot be successfully utilized in accordance with the old constructions and demand new considerations for their utilization in small compact stationary or rotatable loops of high efficiency.

One object of the invention is to provide new constructions of loop antennas employing ferrite materials.

Another object is to provide such antenna suitable for their uses as directional rotating antennas.

Still another object is to overcome certain undesirable characteristics of the combination, and finally to provide simple and efficient means of collecting the currents generated in said antennas.

The invention will be better understood if reference is made to the accompanying drawings in which:

Fig. 1 shows one construction of ferrite loop antenna suitable for rotational use,

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Fig. 2 shows a modification of the first antenna for a stationary use,

Fig. 3 shows a modification adaptable for airborne outside installation.

Fig. 4 shows an antenna embodying a novel collecting arrangement.

Referring now to Fig. 1 the antenna consists of an elongated, preferably cylindrical, rods 1 placed coaxially around which rods pick-up coils 2 are wound directly on the core, over major portion of core length. To prevent the magnetic lines closing on itself through the core the wire must be sufficiently spaced from the surface of the core, which spacing may be accomplished by employment of thick wrapping or insulation of the wire, this being not less than 10 thousands and not more than 50 thousands of an inch. To prevent losses high quality insulation should be used. The ferrite materials of initial permeability from 100 to 500 can be obtained by mixing oxides of the following:

a. 15–30% NiO+20–30% ZnO+balance of Fe_2O_3
b. 15–30% MgO+20–30% ZnO+balance of Fe_2O_3

the mixtures of the above materials being first calcined then re-powdered, pressed to shape and cintered at high temperatures. The reduction of second element with corresponding increase of the first will decrease permeability and magnetic losses with increased stability.

The loop of the Fig. 1 has the following dimensions and characteristics: total length 12″, diameter ½″, number of turns 22 for an inductance of 25 μh. with an effective permeability of 40 if initial permeability is 500. Such loop is more suitable for "low impedance" operation such as used in aircraft directional finding. For high impedance operation (directly tuned) the material having initial permeability of 100 is more suitable to produce lower losses in the circuit, in which case additionally Litz wire is recommended, as the number of turns is increased to 50 for an inductance of 250 μh., while effective permeability is reduced to 25 in such material.

Unlike the inductance coils with core when efficient coils are produced with minimum turns, the loop with ferrite core requires the greatest number of turns for a given inductance in accordance with the formula

$$h_{eff}=\frac{2\pi N A \mu_{eff}}{\lambda}$$

where A is the area of the cross-section of the loop and λ is the wavelength of radiations. One can see that the pick-up is proportional to the number of turns N so that a spreading of turns over a considerable length of the core is beneficial. Over and above the gain realized through spacing of turns and μ_{eff} due to core the elongated loops exhibit greater sensitivity than calculated, which is probably due to the greater volume of space from which the energy is collected. Thus the loop of the above quoted dimensions has a sensitivity equal to an air cored loop having a diameter of 8''.

Should we desire to further increase the sensitivity, the over-all dimensions of the loop of Fig. 1 could be doubled in which case the loop becomes equivalent to an aircored loop of 16'' in diameter, yet its diameter becomes 1'' with length of 24''. Such loop, as shown on Fig. 2 cannot be easily rotated and it is best suited for a "homing device" (operating on a zero signal when a 'plane is headed home). During the homing course in order to receive signals from the transmitting source of the destination a second partially air cored loop 8 can be wound at right angle to the first one. Both loops then can be enclosed in a streamlined casing in the shape of a fin 7 in which both loops can be molded together. High permeability ferrites especially at their high degree of utilization are subject to a considerable fluctuation of permeability with temperature. In most of ferrite this fluctuation is of positive sign, i. e. increasing permeability and inductance with increase of temperature, making the circuits unstable. To compensate for this effect the elongated cores are made in two sections with small gap between adjacent ends. Both sections are held together by means of clasps 3 connected between themselves and with rotatable shaft by means of a strip 4 of the material of high temperature expansion coefficient (hard rubber, certain plastics, bi-metal strip). Thus it is possible to compensate the variations in inductance with temperature as it increases, cause two portions to move apart. A gap of $^{25}\!/_{1000}$'' reduces the inductance by 10%.

While the above two figures represent the maximum utilization of magnetic material the loop shown on Fig. 3 represents a departure in which the effective permeability is reduced to 12–15 by shortening the loop and increasing its area which expedients not only facilitate the rotation of the loop in a small space but also decrease the fluctuation in magnetic properties to an extent making it possible to use same within limited temperature fluctuations. The loop is given a shape of a shallow boat of small vertical height but of increased width. In order to reduce its rotational space the loop is given rounded edges the winding being placed along the linear sides only. Such loop when intended for wide temperature range may be again cut into two sections with a thermal expansion strip holding the sections and the shaft.

This type of the loop may be further modified by providing a round recess 9 in the middle into which a compensating piece of the magnetic material 10 of different characteristics is inserted. Fig. 4 shows this arrangement in which in addition both the recess and the circular piece in the form of a spool are provided with windings thus forming a transformer. The primary 11 is connected directly to the loop, both impedances being matched. The secondary 12 is wound over the spool 10 and is made stationary, while the loop is rotated on its shaft 6. Thus a rotary transformer is formed and because of tight coupling an efficient transformation is secured, eliminating conventional commutator type collector with its hazards of imperfect contact and accumulation of moisture. In addition, in low impedance operation the connecting cable possessing a high capacity limits the inductance of the loop. In this case the cable connects to a stationary secondary which can be matched to correspond to low impedance of the cable, thus allowing much greater number of turns in the loop proper.

In the actual construction the following are the dimensional properties of the loop of Figs. 3 and 4: Over all length 6'', height (thickness) ¾'', width 2''; when wound with 13 turns the loop has an inductance of 25 μh. and is equal in pick-up properties to an 8'' air cored loop. Such small loop easily adapts itself to the rotational type either inside or outside of the 'plane. It can be enclosed in a hermetically sealed plastic case 13, the base of which provides the mounting of stationary spool 10 and an elongated bushing 14 secures water tight construction for the shaft. Cable connections 15 are shown protruding through hermetically sealed case 13 and, being stationary can also be sealed permanently.

In all cases of direction finding by the loop antennas it is desirable to shield the loop windings in order to eliminate so-called "antenna effect." Fig. 1 and Fig. 3 shows by 16 such shielding applied in close proximity to the coil, which shielding may be composed of a metal foil or a shielding cloth connected to the ground.

The devices shown on Figs. 2 and 4 can be shielded by applying shielding means to the casing 13 either by interrupted wires laid on the outside surfaces, or by spraying metal or other conducting materials on said surfaces.

The invention herein described by way of preferred examples is not limited to the forms shown in the specification and in the drawings and may be applied to other similar devices.

What I claim is:

1. A directional loop antenna for the reception of high frequency radiations comprising an elongated core of high initial permeability in the form of a flat bar of small thickness with respect to its length and a pick-up coil wound on said core to produce an effective permeability of not less than 10 and not greater than 50 said pick-up coil being spacedly wound substantially through the entire length of said core and spaced from said core by an insulating wrapping, said core having a length not less than 8 times greater than said thickness and the width of said core being greater than thickness and less than core length.

2. A directional loop antenna according to claim 1, characterized in that said core is provided with a magnetic gap.

3. A directional loop antenna according to claim 1, characterized in that the core comprises a plurality of sections made of materials having magnetic characteristics which vary oppositely with the temperature changes.

4. A directional loop antenna according to claim 1, characterized in that the core is in the shape of a flat bar with rounded ends.

5. A directional rotational antenna according to claim 2 characterized in that said gap is a circular recess in the center of rotation.

6. A directional rotational antenna according to claim 5 characterized in that in said recess a round section is provided with two windings to form a rotary transformer for coupling said loop to a stationary cable.

7. A directional antenna according to claim 2

wherein said gap is formed between two sections of the antenna aligned coaxially, said antenna being provided with means to vary said gap in accordance with temperature fluctuations.

8. A rotational loop antenna according to claim 5 characterized in that a vertical shaft is attached to said core and said antenna is contained in a hermetically sealed enclosure.

9. A directional antenna according to claim 1 characterized in that the effective permeability is in the range of 10 to 15.

10. A directional loop antenna for the reception of high frequency radiations comprising an elongated core of high initial permeability in the form of a flat bar with rounded ends and of small thickness with respect to its length and a pick-up coil spacedly wound substantially through the entire linear portion of said core to produce an effective permeability in the range of 10 to 15, said core having a length not less than 8 times greater than thickness and the width of said core being greater than thickness and less than core length.

WLADIMIR J. POLYDOROFF.

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